The Tritium Tempest in a Teapot Notes

Any time there is a tritium leak or discharge from a nuclear reactor facility the anti-nuclear media frightens the public with fictitious stories about the adverse consequences to the environment and human health that will result. Tritium once again became a tempest in a teapot when the anti-nuclear crowd became enraged over the Japanese plan to discharge tritiated wastewater from the Fukushima nuclear power plant accident to the Pacific Ocean. In this presentation students will learn what tritium is and why it is not a legitimate environmental or human health concern.

Slide 4 – Fukushima tritiated water tanks

- as of 2016, about 760 terabecquerels (760 x 10^{12} Becquerels) of tritium contained in 860,000 m^3 (860 million liters) of water stored in tanks – amounts to approximately 2.1 grams of tritium or 14 mL (less than ½ ounce) of tritiated water in 860 million liters of water
  - one Becquerel equal to one disintegration per second; that is, one tritium atom radioactive decay per second

Slide 5 – Fukushima tritiated water controversy

- contaminated water from Fukushima accident treated to reduce all radioactive substances to below regulatory discharge limits except for tritium
- tritiated water (HTO) chemically indistinguishable from normal water (H_2O), so separating HTO from H_2O not economically practical

Slide 6 – isotopes of hydrogen graphic

- as graphic shows, tritium is isotope of hydrogen
  - adding neutrons to protium nucleus only increases mass of hydrogen atom
- natural abundance of protium isotope in hydrogen is 99.985%
  - "normal" water written as H_2O
- natural abundance of deuterium isotope in hydrogen is 0.015%
  - deuterium sometimes called heavy hydrogen because proton and neutron approximately same mass
  - nucleus of deuterium atom called a deuteron
  - "heavy" water, consisting of deuterium and oxygen, written as D_2O
- tritium is radioactive isotope of hydrogen with half-life of 12.3 years

Slide 9 – tritium in drinking water regulatory limits graphic

- slide shows selected regulatory limits for tritium in drinking water
- note that Japanese regulatory limit one of highest at 60,000 Bq/L

Slide 10 – tritium biological facts

- 18.6 keV of energy distributed between beta particle and associated anti-neutrino, with beta energy being only 5.7 keV
- beta particle range less than diameter of human cell
- tritium has very small probability of causing any damage in biological matter

Slide 15 – natural radioactivity in food

- slide shows K-40 activity of selected food items
- activity given in pico-Curies per kilogram, where 1 pCi = 0.037 Bq
- naturally occurring radioactive radium also present in some foods

Slide 16 – gastrointestinal (GI) absorption of radionuclides

- slide shows absorption of selected radionuclides in gastrointestinal tract
- human intake of C-14 and K-40 primarily through GI tract, which allows these radionuclides to be distributed throughout body

Slide 17 – biological radionuclide excretion pathways

- slide shows body's normal pathways for excretion of radionuclides
- normal metabolism processes result in C-14, and K-40 entering body's blood stream, where ultimately removed from blood via lungs and kidneys, respectively
- as already indicated, primary excretion pathways are
  - urine, sweat, and exhalation for tritium
  - feces and exhalation for C-14
  - urine for K-40

Slide 18 – radioactive elements in human body

- table shows both C-14 and K-40 activities within human body much greater than tritium activity
- note radium-226 table entry
  - biological half-life of about 45 years
  - emits alpha particle and gamma-ray (internal alpha radiation potentially more damaging than internal beta radiation)
  - has similar activity in body to tritium, but not considered health hazard
- if C-14, K-40, and Ra-226 not considered health hazards, then tritium not a health hazard

Slide 21 – annual discharge of tritium from nuclear facilities

- slide shows annual tritium discharges to bodies of water from nuclear facilities around world
- note that 760 TBq of tritium at Fukushima is much smaller than very large annual tritium activity release from La Hague nuclear fuel reprocessing plant in France (11,400 TBq) and about same

as annual activity release from Bruce Nuclear Generating Station in Canada (756 TBq) – neither of these tritium releases produce any public outrage

- TBq (terabecquerel) is 10^{12} Bq